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Final Progress Report: Some studies of Structure and Dynamics of Jupiter's magnetosphere

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Progress over the duration of the project

The purpose of this investigation was to establish the relative roles of solar wind and the internal plasma processes in shaping the structure and dynamics of Jupiter's magnetosphere. We carried out several investigations to establish these roles. Three new research papers have resulted from this work. In the following we provide brief summaries of the main findings.

The influence of solar wind on currents in Jupiter's magnetosphere

For this purpose, we used the magnetic field observations from all of the pre-Galileo spacecraft and from the Galileo Prime and GEM missions to compute the electric current density in the equatorial plane of Jupiter's magnetosphere by making certain appropriate assumptions. We have found that in the middle magnetosphere, the azimuthal currents are much stronger on the nightside (~ 144 MA between the radial distances of 10 and 50 R_J) than they are on the dayside (~ 88 MA in the same distance range). From current continuity considerations, we conclude that the nightside partial ring current is fed and emptied by field-aligned currents in the dusk and the dawn sectors, respectively. These currents are similar (but opposite in polarity) to Region 2 field-aligned currents observed in the Earth's magnetosphere. Because, the presence of Region 1 or Region 2 sense field-aligned currents in a magnetosphere indicates the presence of solar wind driven convection in a magnetosphere, a surprising conclusion of the present analysis is that the solar wind influence reaches deep into the heart of Jupiter's magnetosphere.

Other findings of this study are: (1) The equatorial field strength is remarkably constant over all local times; (2) The equatorial source of the outward field-aligned currents required for the generation of aurorae is located between the radial distances of 10 and 30 R_J with a peak near 20 R_J; (3) The Jovian magnetosphere displays a magnetic field configuration intermediate to a Parker spiral and a magnetosphere driven by solar wind.

The results from this investigation have appeared in Khurana (2001, JGR).

Magnetic field in Jovian magnetotail

Magnetometer data acquired as the Galileo Orbiter apoapsis rotated from dawn to dusk across the magnetotail of the Jovian magnetosphere between late 1995 and the end of May 2000 were used to characterize the magnetic field and the distribution of magnetic pressure in the inner part of the Jovian magnetotail. The distances probed extend to ~150 R_J or roughly three times the distance to the nose of the magnetopause, analogous to distances within 30 R_E in the magnetotail of Earth. The magnetic pressure in the center of the plasma sheet is typically almost an order of magnitude smaller than the lobe pressure, which therefore is roughly equal to the peak thermal plasma pressure in the plasma sheet. The pressure decrease with radial distance can be described roughly as a power law with an exponent of −2.8, and the maximum field magnitude decreases with distance to the −1.4. We showed that near 150 R_J, only about 30% of the magnetic flux remaining in the lobes closes across the plasma sheet beyond 150 R_J. If we use our previous results from Voyager 1 and 2 (Khurana and Kivelson, 1989), the B_z value is ~ 0.3 nT at 100 R_J in the dawn sector. So in the dawn sector most of the flux may remain open beyond 100 R_J. Systematic asymmetries of the field structure and magnetic pressure across the midnight meridian in the region beyond 25 R_J downtail are notable, with the flux tubes being less stretched (with larger equatorial B_z) near dusk than near dawn. The lobe pressure attains its minimum value in the dusk sector where the plasma sheet magnetic pressure maximizes.

A brief report summarizing the results of this investigation will appear in JGR where it is currently in press (Kivelson and Khurana , 2002).

Sheared magnetic field structure in Jupiter's dusk magnetosphere

The configuration of the magnetic field in the dusk sector of the Jovian magnetosphere varies with distance from the equatorial current sheet. The changing twist out of meridian planes is consistent with flows that lag corotation near the equator and lead corotation at higher latitudes. The field-aligned current needed to account for the changing twist out of meridian planes flows toward Jupiter's ionosphere at distances beyond 100 R_J. The observations are consistent both qualitatively and quantitatively with the expectation that currents flowing from Jupiter's ionosphere toward the equator within 30 R_J are linked to currents flowing away from the equator at large radial distances.

For roughly 30 hours in December 2000 during an interval of quiescent solar wind, the Jovian plasmasheet was displaced northward of its normal near-equatorial position, leaving Galileo in the dusk side southern magnetic hemisphere for several planetary rotations. During this fortuitous event, the orientation of the field varied systematically in a way that enabled us to describe how the magnetic structure varies with distance from the current sheet and to identify the currents required to complete the current system that imposes partial corotation on the plasmasheet. The analysis accounts for the differing field orientations reported from the Galileo observations near the equatorial plane and those reported at higher latitudes from Ulysses. The shear in the azimuthal field component was found to be consistent with the presence of ~10 MA field-aligned currents flowing from the current sheet into less than 2° of latitude in the Jovian ionosphere poleward of the zone of equatorward current flow associated with the main oval.

The results from this investigation will appear in a research paper to appear in JGR (Kivelson et al., 2002, in press).

References

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Kivelson, M. G. and K. K. Khurana, Properties of the Magnetic Field in the Jovian Magnetotail, paper in press, *J. Geophys. Res*, 2002.

Kivelson M. G., K. K. Khurana, and R. J. Walker, Sheared magnetic field structure in Jupiter's dusk magnetosphere: Implications for return currents, paper in press, *J. Geophys. Res*, 2002.

Research articles resulting from this investigation

Khurana, K. K., The influence of solar wind on Jupiter's magnetosphere deduced from currents in the equatorial plane, J. Geophys. Res., 106, 25999, 2001.

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Talks presented at scientific meetings

Khurana, K. K., The configuration of Jupiter's magnetosphere as deduced from Galileo's magnetic field observations, paper presented at the EGS meeting in The Hague, Netherlands. 1999.

Khurana, K. K., The nature and strength of field-aligned currents in Jupiter's magnetosphere, Paper presented at the Spring AGU meeting in Boston, 1999.

Khurana, K. K., An assessment of electric currents flowing in Jupiter's magnetosphere from magnetometer data, Paper presented at the conference on Magnetosphere of the Outer Planets (MOP) in Paris, 1999.

Khurana, K. K., Asymmetries and Variations in Jupiter's Magnetosphere, paper presented at the EGS meeting in Nice, France. 2000.

Khurana, K. K., Plasma Convection in Jupiter's Magnetosphere, Paper presented at the Fall AGU meeting in San Francisco, 2000.